This study has been developed under the European Investment Bank (EIB) STARBEI funding program. Usual disclaimer applies

Source: http://www.pikeresearch.com/research/green-telecom-networks

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Bangkok, Thailand

ECONOMICS AND FORECAST OF ENERGY CONSUMPTION IN NGN NETWORKS: THE CASE OF SPAIN

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European Investment Bank

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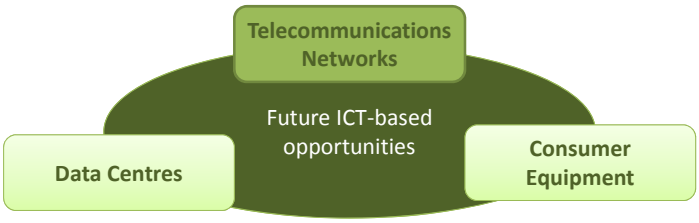
Introduction

- **Reducing energy consumption** is one of the main goals of sustainability planning in most countries. For instance in Europe, the EC established the objectives in the Communication "20 20 by 2020 Europe's climate change opportunity".



- Next Generation Networks (NGN) → **One of the most relevant upcoming ICT developments**
- The role of energy consumption seems mostly **absent** from the main analysis and the debate on NGN deployment.

Research questions

- Which **design parameters** affect the level of energy consumed in NGN? How?
- Does energy consumption impact **fixed and mobile** access networks differently? How to compare them?
- How does energy consumption affect NGANs **capital and operational expenses**?

Energy consumption framework

NGAN energy consumption baseline model

Choice of technologies, Network design & deployment, Active devices, Demographic framework, …

Prospective scenario

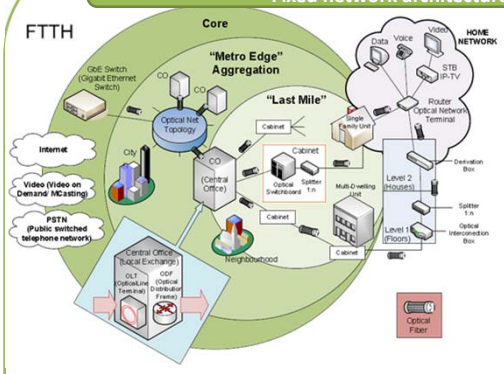
Demand forecasting
using growth models according to actual data of the Spanish market

Traffic evolution
and congestion model

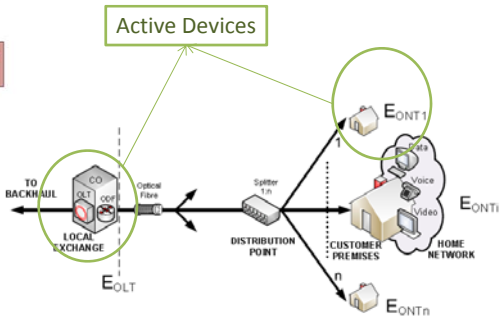
Other parameters variations

RESULTS
Energy consumption cost for the 2011-2015 period
Energy consumed and cost per subscriber – Sensitivity analysis
Comparison with network related expenses

Choice of Access Technologies
Fixed network architecture

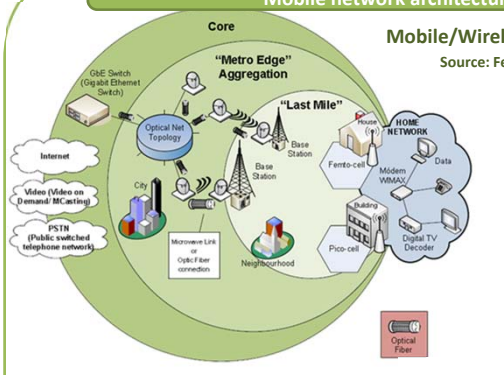


Fixed network architecture.
Source: Feijóo and Gómez-Barroso 2010

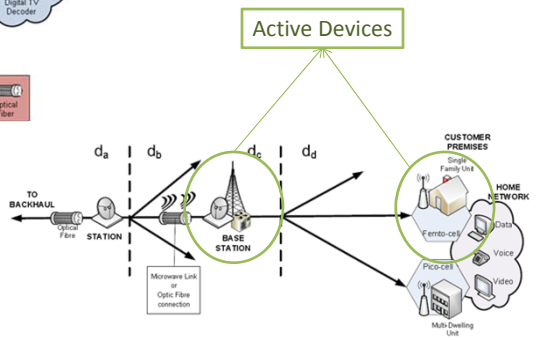


FTTH network architecture for energy consumption calculations.

Choice of Access Technologies
Mobile network architecture

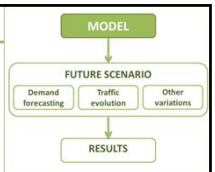


Mobile/Wireless 4G network architecture.
Source: Feijóo and Gómez-Barroso 2010



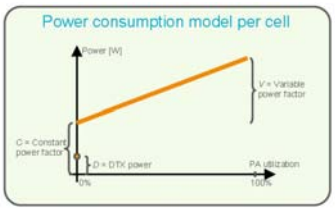
Mobile network architecture for energy consumption calculations.

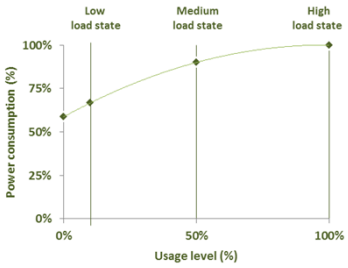
Active device energy profiles



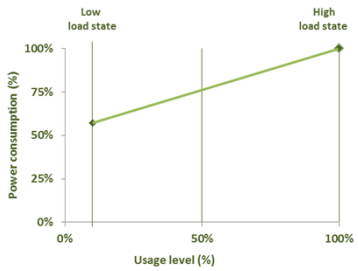
Reference idea

Source:
Frenger, P., Moberg, P., Malmodin, J., et al. (2011). "Reducing Energy Consumption in LTE with Cell DTX".



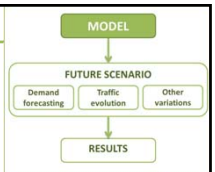


Base Stations energy consumption model

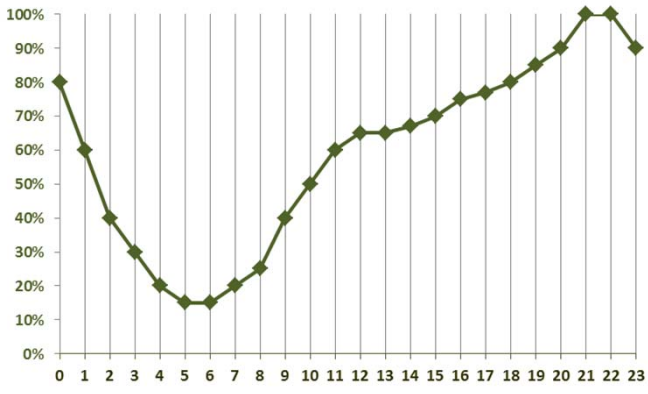


ONTs, OLTs and Femtocell energy consumption model

Network daily usage

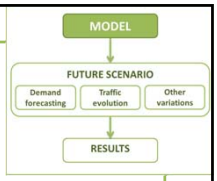


- Average daily profile of network usage



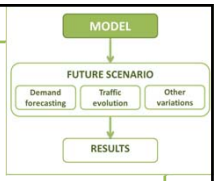
Data traffic variation during a day
Source: Project EARTH (2011)

Energy Prices



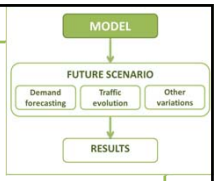
- Main parameter to transform energy consumption units into operational expenditure → **Price of the energy.**
- The value used in the model is **0.14 €/KWh** (reference level in the Spanish energy market in 2011).
- In general the **forecasts** of energy prices suggest an **increase of 50% in 2030 compared to the levels in 2005**. *("EU energy trends to 2030"[EC, 2009] & "Energy 2020. A strategy for competitive, sustainable and secure energy" [EC, 2010]*).

Network Design Parameters
Baseline Scenario



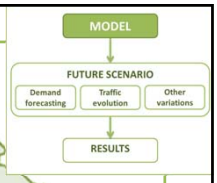
Parameters	Fixed NGANs 	Mobile NGANs 
Guaranteed QoS (Mbps)	30	1
Data traffic 2012 (%)	91%	9%
Target penetration (lines per 100 inhabitants)	80%	130%
Allocated Spectrum Bandwidth (MHz)	-	20
Spectral Efficiency (bps/Hz)	-	15

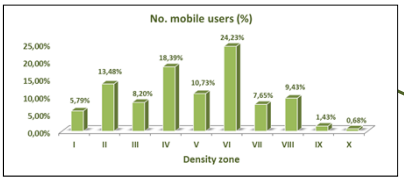
Demographic framework

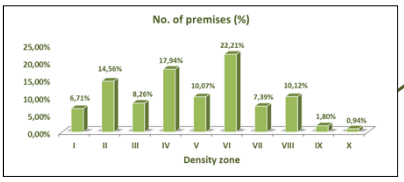


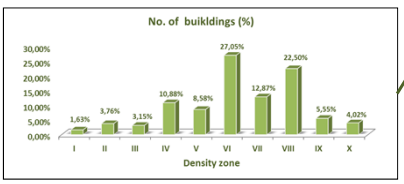
- **Spain** is used as a case study (applicable without major modifications to other similar countries).
- Classification in **10 geographical zones** with **population density** as the basic parameter.
- The model allows for more precise **estimations in the areas where only one broadband network operator is present**
- **To improve the lack of information on buildings clustering**, mainly for suburban and rural areas → Division of each zone in **2 different geotypes "A" & "B"**

Demographic framework in numbers



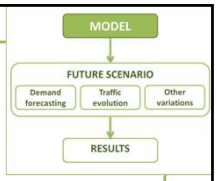






SPAIN	
Number of municipalities	8112
Total population (inhabitants)	46.745.807
Mobile penetration rate (CMT, October 2010)	121%
Total number of mobile users	56.562.426
Number of households an businesses	17.950.398
Global average mobile users per premise	3,15
Number of buildings	9.285.007
Global average mobile users per building	10,08
Average population (inhabitants per municipality)	5.763
Total surface (km2)	504.677
Average surface per municipality (km2)	62,21

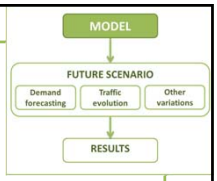
Deployment strategy - User allocation



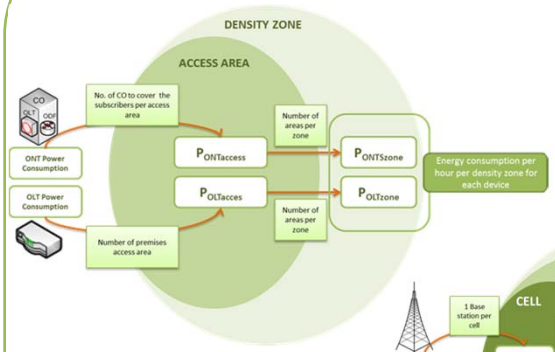
- From penetration, the market share fixes the maximum number of users subscribed to the operators' network.
- The operator can follow different deployment strategies (combinations for the number of users in the different zones to achieve its overall target).
  - As deployment costs per user are inversely related with population density, the most rational strategy of the operator would be to start the deployment in those areas with **higher population density**.

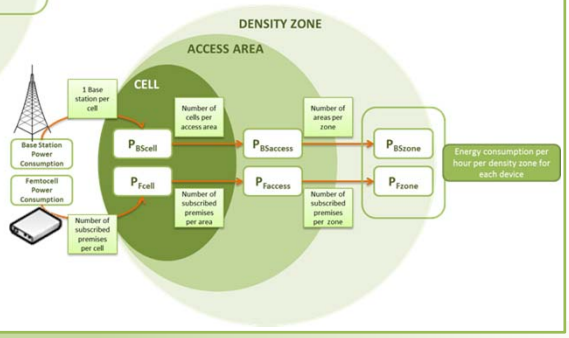
    Baseline Scenario
  - As a consequence of diverse types of **regulatory conditions**., some constraints could be set. i.e. increasing coverage to rural areas (low pop. density zones).

Calculation Process (1/2)
Energy consumption per hour

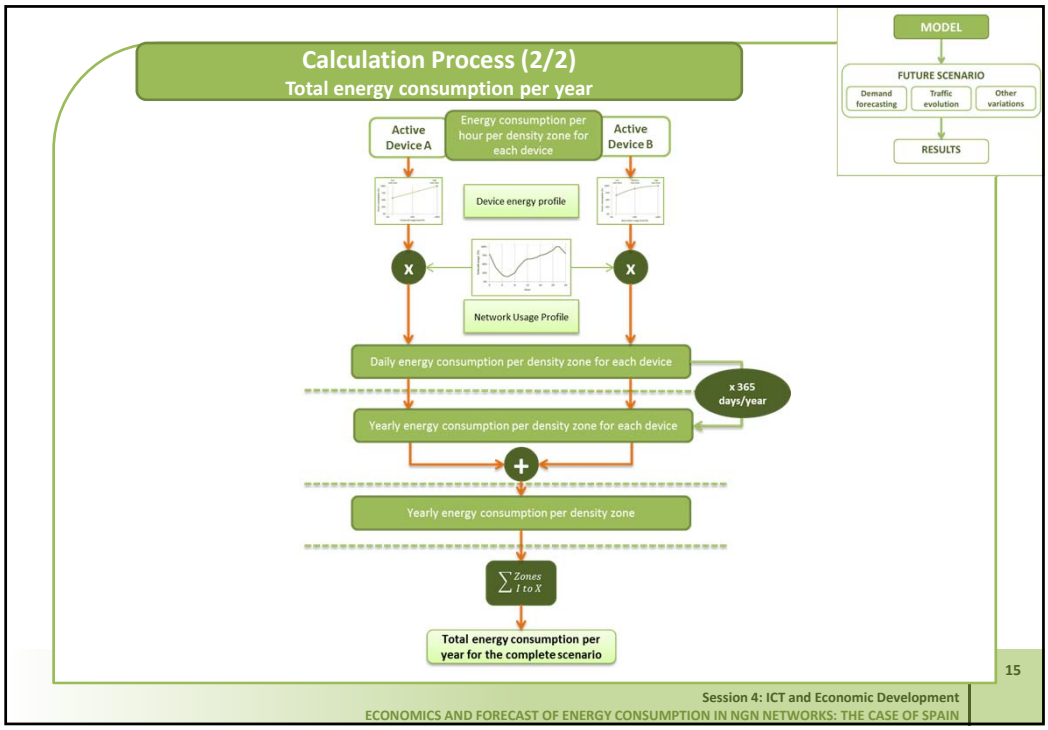


Fixed NGANs





Mobile NGANs


MODEL
FUTURE SCENARIO
Demand forecasting
Traffic evolution
Other variations
RESULTS
Calculation Process (2/2)
Total energy consumption per year
Active Device A
Energy consumption per hour per density zone for each device
Active Device B
Device energy profile
X
X
Network Usage Profile
Daily energy consumption per density zone for each device
x 365 days/year
Yearly energy consumption per density zone for each device
+
Yearly energy consumption per density zone
∑ Zones 1 to X
Total energy consumption per year for the complete scenario
15
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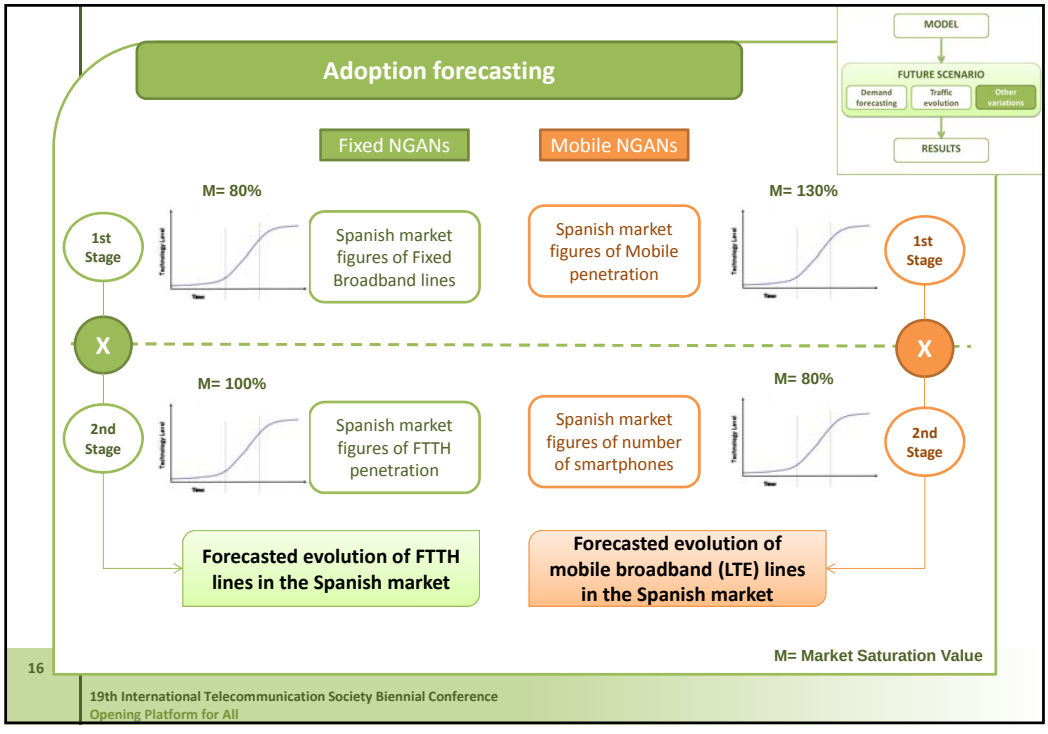
MODEL
FUTURE SCENARIO
Demand forecasting
Traffic evolution
Other variations
RESULTS
Adoption forecasting
Fixed NGANs
Mobile NGANs
M= 80%
1st Stage
Spanish market figures of Fixed Broadband lines
Spanish market figures of Mobile penetration
M= 130%
1st Stage
X
X
M= 100%
2nd Stage
Spanish market figures of FTTH penetration
Spanish market figures of number of smartphones
M= 80%
2nd Stage
Forecasted evolution of FTTH lines in the Spanish market
Forecasted evolution of mobile broadband (LTE) lines in the Spanish market
M= Market Saturation Value
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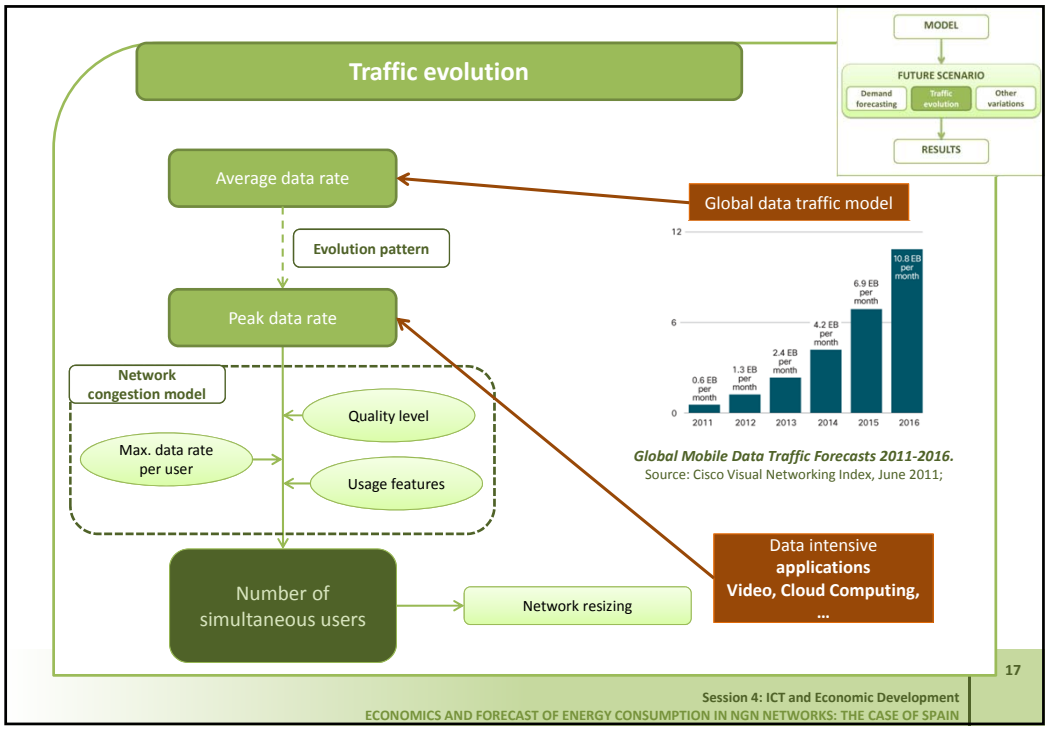
Traffic evolution
MODEL
FUTURE SCENARIO
Demand forecasting
Traffic evolution
Other variations
RESULTS
Average data rate
Global data traffic model
Evolution pattern
Peak data rate
Network congestion model
Quality level
Max. data rate per user
Usage features
Number of simultaneous users
Network resizing
Data intensive applications Video, Cloud Computing, ...
12
6
0
0.6 EB per month
1.3 EB per month
2.4 EB per month
4.2 EB per month
6.9 EB per month
10.8 EB per month
2011
2012
2013
2014
2015
2016
Global Mobile Data Traffic Forecasts 2011-2016.
Source: Cisco Visual Networking Index, June 2011;
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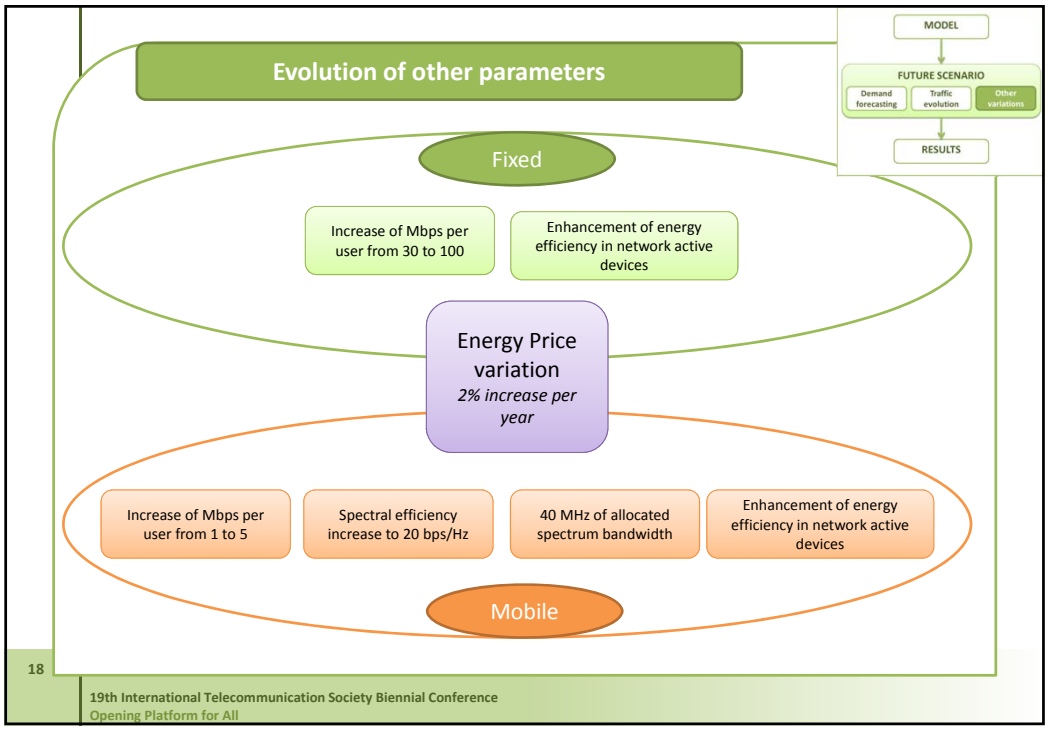
Evolution of other parameters
MODEL
FUTURE SCENARIO
Demand forecasting
Traffic evolution
Other variations
RESULTS
Fixed
Increase of Mbps per user from 30 to 100
Enhancement of energy efficiency in network active devices
Energy Price variation
2% increase per year
Increase of Mbps per user from 1 to 5
Spectral efficiency increase to 20 bps/Hz
40 MHz of allocated spectrum bandwidth
Enhancement of energy efficiency in network active devices
Mobile
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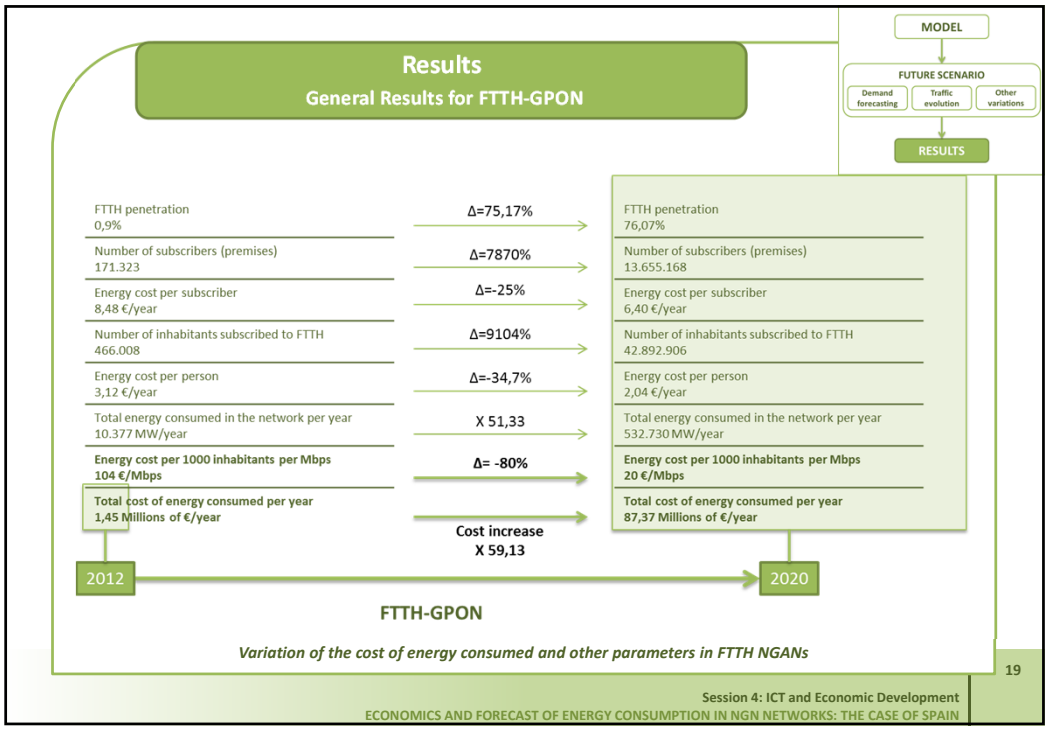
MODEL
FUTURE SCENARIO
Demand forecasting
Traffic evolution
Other variations
RESULTS
Results
General Results for FTTH-GPON
FTTH penetration 0,9%
Δ=75,17%
FTTH penetration 76,07%
Number of subscribers (premises) 171.323
Δ=7870%
Number of subscribers (premises) 13.655.168
Energy cost per subscriber 8,48 €/year
Δ=-25%
Energy cost per subscriber 6,40 €/year
Number of inhabitants subscribed to FTTH 466.008
Δ=9104%
Number of inhabitants subscribed to FTTH 42.892.906
Energy cost per person 3,12 €/year
Δ=-34,7%
Energy cost per person 2,04 €/year
Total energy consumed in the network per year 10.377 MW/year
X 51,33
Total energy consumed in the network per year 532.730 MW/year
Energy cost per 1000 inhabitants per Mbps 104 €/Mbps
Δ= -80%
Energy cost per 1000 inhabitants per Mbps 20 €/Mbps
Total cost of energy consumed per year 1,45 Millions of €/year
Cost increase X 59,13
Total cost of energy consumed per year 87,37 Millions of €/year
2012
2020
FTTH-GPON
Variation of the cost of energy consumed and other parameters in FTTH NGANs
19
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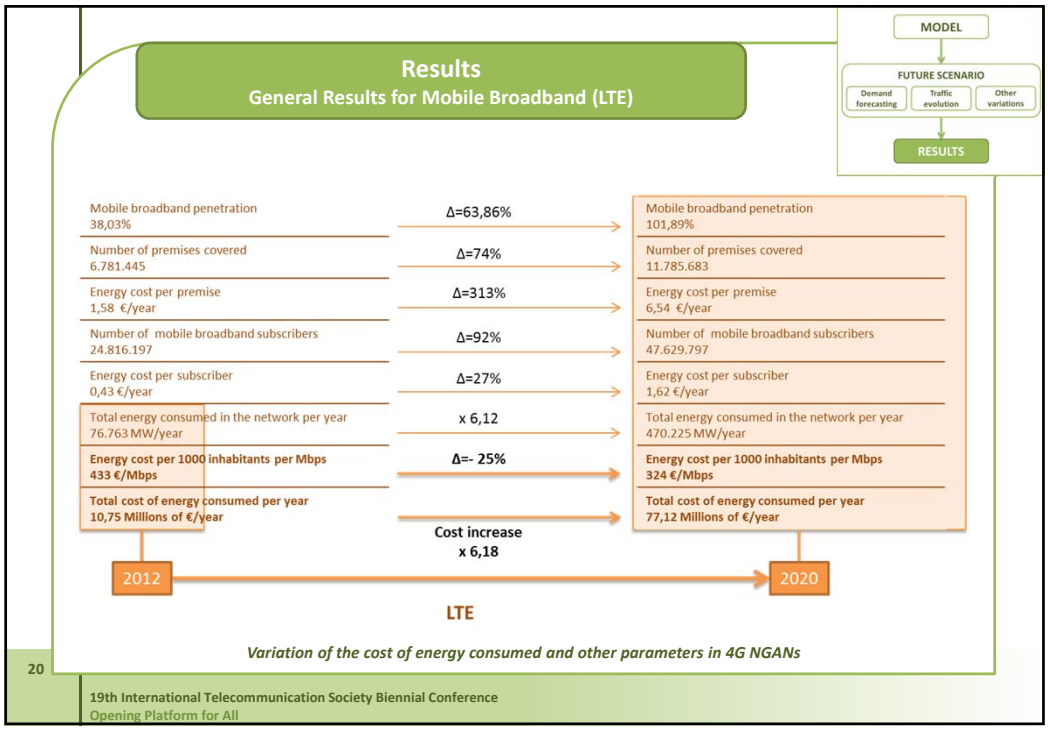
MODEL
FUTURE SCENARIO
Demand forecasting
Traffic evolution
Other variations
RESULTS
Results
General Results for Mobile Broadband (LTE)
Mobile broadband penetration 38,03%
Δ=63,86%
Mobile broadband penetration 101,89%
Number of premises covered 6.781.445
Δ=74%
Number of premises covered 11.785.683
Energy cost per premise 1,58 €/year
Δ=313%
Energy cost per premise 6,54 €/year
Number of mobile broadband subscribers 24.816.197
Δ=92%
Number of mobile broadband subscribers 47.629.797
Energy cost per subscriber 0,43 €/year
Δ=27%
Energy cost per subscriber 1,62 €/year
Total energy consumed in the network per year 76.763 MW/year
x 6,12
Total energy consumed in the network per year 470.225 MW/year
Energy cost per 1000 inhabitants per Mbps 433 €/Mbps
Δ=- 25%
Energy cost per 1000 inhabitants per Mbps 324 €/Mbps
Total cost of energy consumed per year 10,75 Millions of €/year
Cost increase x 6,18
Total cost of energy consumed per year 77,12 Millions of €/year
2012
2020
LTE
Variation of the cost of energy consumed and other parameters in 4G NGANs
20
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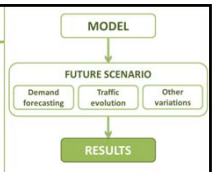
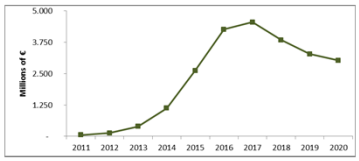
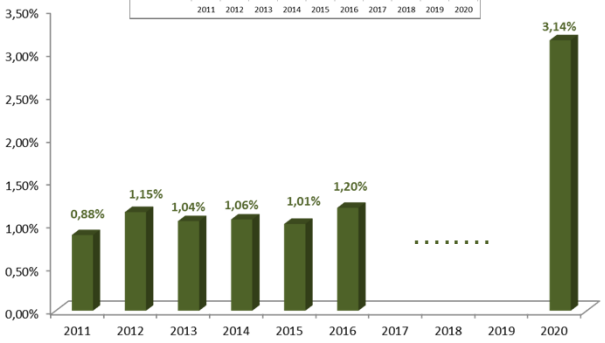
Results
Comparisons over network expenditures - FTTH



Evolution of total network costs

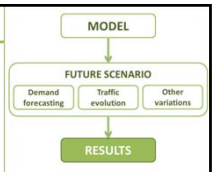




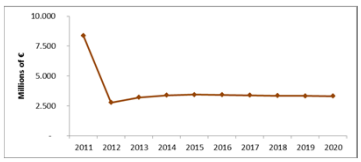
Network costs	Millions of €
CAPEX	9.951
OPEX	13.314
Total	23.266

Evolution of the cost of energy consumption (%) regarding network CAPEX+OPEX

Results
Comparisons over network expenditures - LTE



Evolution of total network costs

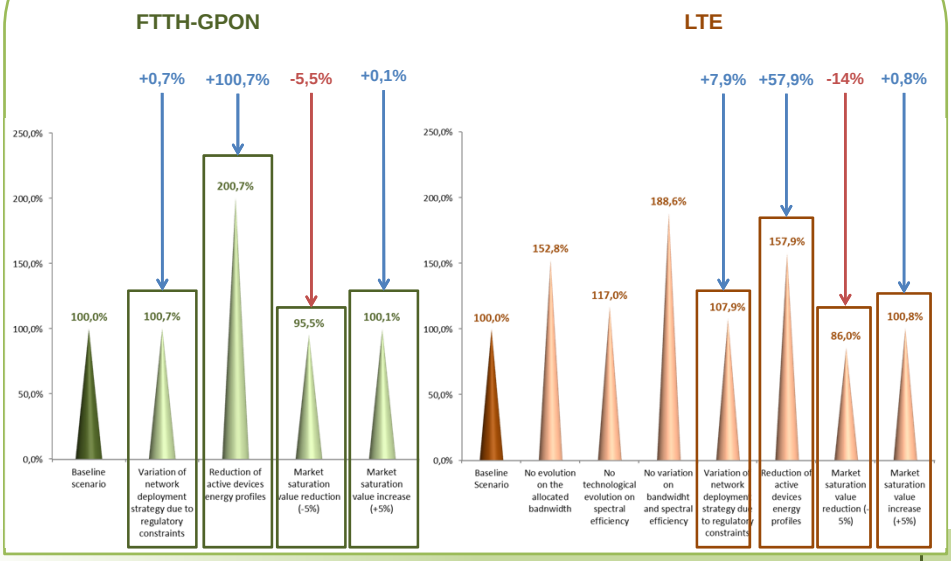


Network costs	Millions of €
CAPEX	10.953
OPEX	27.032
Total	37.985

Evolution of the cost of energy consumption (%) regarding network CAPEX+OPEX

Results

Sensitivity analysis on the cost of energy consumption



Conclusions (I)

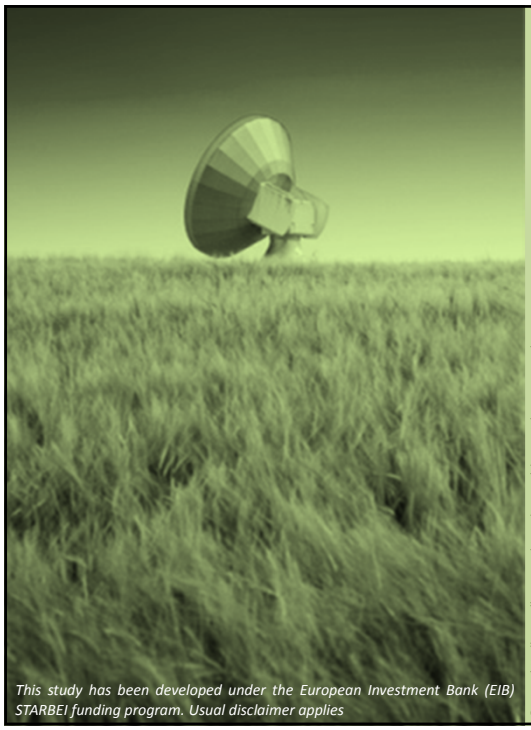
- Energy considerations have held a very **limited role** in the **planning, management and regulation** of NGNs, so far .
- If NGNs are to play a **sustainable** role in the future, then the energy consumption of NGNs–and their cost–must **not be overlooked**.
- At the same time, citizens are ever more conscious of their role in building a more sustainable society. For many of them, energy-saving aspects are becoming a factor to be considered in **consumption decisions**.

Conclusions (II)

- This paper has introduced a **model for the assessment of the energy** consumed by access networks in a practical setting. The baseline hints at both **technological and policy enhancements** to reduce the level of consumption in NGNs:
  - Obvious solution: improving the **energy profiles** of the devices used in the network rollout. This can be reached through a continuation of existing policies on energy efficient network devices.
  - The baseline also shows that other factors influencing energy consumption in the network have an even greater importance than active device consumption. In particular, the **technological features of networks**, such as the spectral efficiency and frequency bandwidth allocated to operators, **strategic decisions** such as QoS and the order of **coverage** for areas in the deployment
  - **Policy** also has a considerable influence; some key parameters of networks design depend on **regulatory decisions**. Two examples have been considered in this paper: the case of frequency bandwidth allocated to mobile operators and the regulatory influence (for instance, license conditions) in the rollout strategy.

Conclusions (III)

- Results show that the energy used in fixed networks is higher than in mobile networks within the baseline described. However, if the **cost of energy per subscriber per Mbps** is considered, **FTTH-GPON is considerably more efficient**, and therefore, under this perspective, these technologies are more sustainable.
- **Users lack this information** and, in general, know little or nothing about the energy impact of their increasing usage of networks and devices, as well as the associated costs and effects on sustainability. In other words, they miss a key piece in making an informed decision.
- Against this background, the paper has attempted to place energy considerations in the forefront of the debate and, from the authors' perspective, has shown that **providing transparent information to consumers on their usage of ICT networks and devices is feasible and relevant**.



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Source: http://www.pkeresearch.com/research/green-telecom-networks

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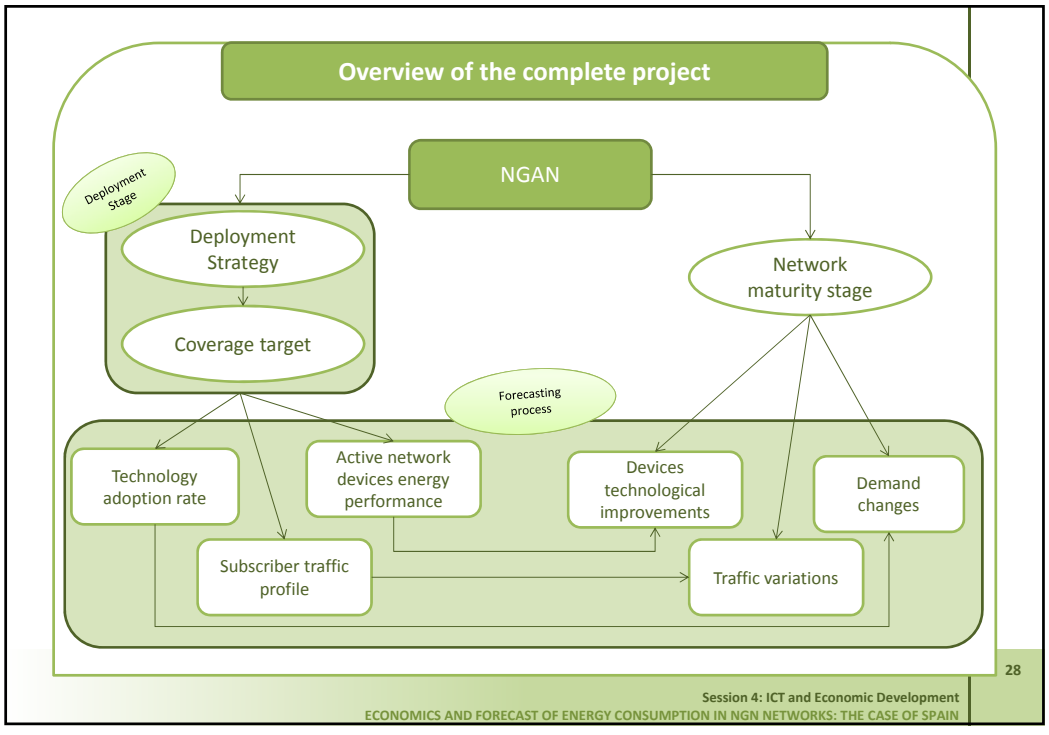

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Session 4: ICT and Economic Development
ECONOMICS AND FORECAST OF ENERGY CONSUMPTION IN NGN NETWORKS: THE CASE OF SPAIN

Motivation

- Comparison of energy consumption of available technologies for NGANs deployments
- Variation of the design parameters:
  - ***Demand***
  - ***Traffic***
  - ***Usage during the day***
  - ***Device energy consumption***
- Temporal scenario

- **Definition and combination** of design parameters and prospective evolution of the baseline model proposed.
- Results would help us determine the **impact** of each factor on the related costs of energy consumption.